Multi-Functional 3-D Printed Customized Luneburg Lens Antennas for Future Earth Science Applications

Completed Technology Project (2016 - 2018)

Project Introduction

This research project develops a practical multi-band scanning lens beamforming array antenna based on the principle of a Luneburg Lens (LL). Modern nature-inspired optimization methods and additive manufacturing methods enable design of non-spherical lenses in order to reduce mass and volume. New lens designs enable rapid beam scan and multi-beam antenna technology by using an array of electronic modules. The new technology will overcome mechanical scan rate and beam agility limitations that currently limits radar performance.

The goal of this research is practical multi-band scanning antenna technology that can replace complex mechanical scanning assemblies such as the mechanically spun reflectors used to achieve conical scanning on QuikScat/RapidScat class of scatterometers. Mechanical scan systems have proven to be the key single point failure that limited mission lifetime. Moreover, the new technology will overcome mechanical scan limitations beam agility and scan rate that limits radar performance. The approach in this research is a lens beamforming array based on the principle of a Luneburg Lens (LL) that is capable of full 2D scan. The classical LL is an inhomogeneous sphere in which the dielectric constant decreases with distance from the center, providing extremely large bandwidth, unlimited scan range and no scan loss. This research uses modern nature-inspired optimization methods in conjunction with additive manufacturing methods to extend the advantages of LL technology to non-spherical lenses in order to reduce mass and volume. These new lens designs form the basis of a new class of beam scan and multi-beam antenna technology which utilizes an array of electronic modules in order to provide rapid beam switching and scanning.

Anticipated Benefits

Antenna technology is a key enabler for NASA Planetary and Earth Science remote sensing missions. Examples of NASA missions enabled by advances in antenna technology include scatterometers, such as QuikScat and RapidScat, and Earth Science Radars and Radiometers such as Soil Moisture Active Passive (SMAP). These systems all rely on mechanical scanning antenna technology. Mechanical scanning imposes limitations on the system design and lifetime. This research provides critical practical active beam scanning technology to enable next generation remote sensors.

Commercial satellite telecom systems regularly use multi-beam antennas and beam synthesis methods to provide coverage over specified geographical regions of the Earth. This is typically accomplished with cluster feed reflector antennas in GEO orbits. The technology developed in this research has potential to provide an alternative that can cover broader coverage with better performance. Furthermore, the array lens technology may enable special purpose communications satellites in MEO or LEO orbits.

Project Image
JPL_IRAD_Activities Project

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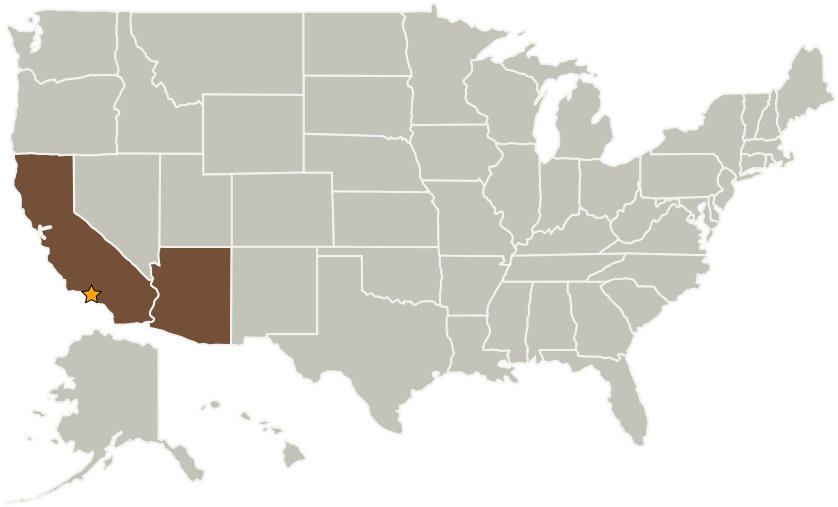
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Jet Propulsion Laboratory(JPL)	Lead Organization	NASA Center	Pasadena, California

Primary U.S. Work Locations	
Arizona	California

Organizational Responsibility

Responsible Mission Directorate:

Mission Support Directorate (MSD)

Lead Center / Facility:

Jet Propulsion Laboratory (JPL)

Responsible Program:

Center Independent Research & Development: JPL IRAD

Project Management

Program Manager:

Fred Y Hadaegh

Project Manager:

Fred Y Hadaegh

Principal Investigator:

Richard E Hodges

Co-Investigators:

Douglas C Hofmann
Yahya Rahmat-samii

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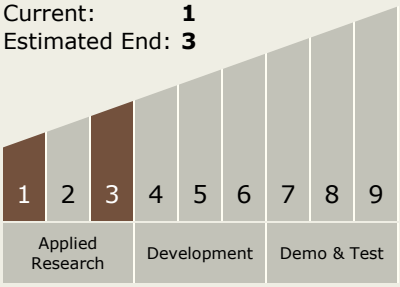
Images

JPL_IRAD_Activities Project Image
Project Image JPL_IRAD_Activities Project
(https://techport.nasa.gov/image/26094)

Technology Maturity (TRL)

Start: **1**
Current: **1**
Estimated End: **3**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.2 Observatories
    - TX08.2.2 Structures and Antennas

Target Destinations

Earth, Others Inside the Solar System

Supported Mission Type

Push